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Structure and taxonomy of the genus *Delosina* Wiesner, 1931 (Protozoa: Foraminiferida)

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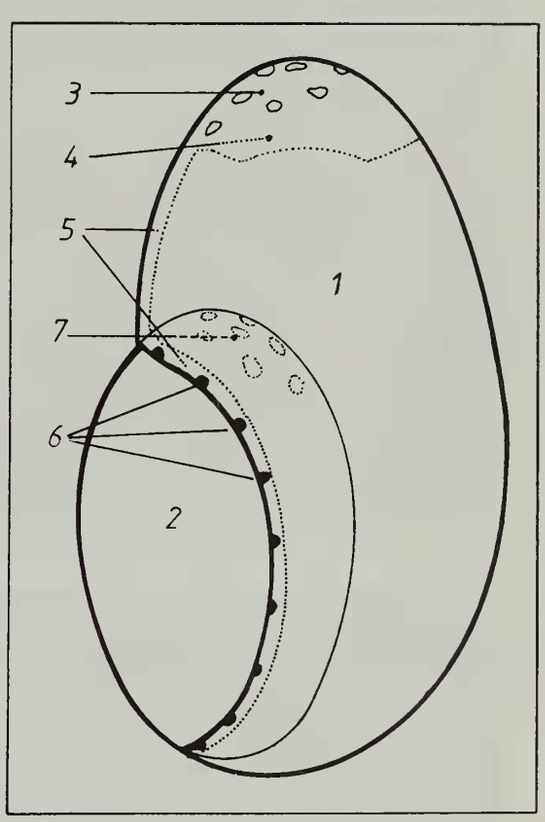
SYNOPSIS. The systematic position of the genus *Delosina* is reassessed in the light of structural and morphological observations. The non-lamellar wall structure and a new type of wall ultra-structure leads to the proposal of a new, separate suborder, the Delosinina. The species *Delosina complexa, D. complanata*, *D. sutilis* and *D. wiesneri* are emended and lectotypes are designated and described. *D. polymorphinoides* is synonymised with *D. complexa*.

INTRODUCTION

In 1907, Sidebottom described a new species, *Polymorphina (?) complexa*, expressing much puzzlement as to the true affiliation of this unusual taxon. After the initial description, specimens more or less referable to this form were found in a variety of localities, but always as a rare species. Sidebottom corresponded with Earland about the possible relationships of this species (*fide* Earland, 1934, p. 125), from which it appears that Sidebottom contemplated the erection of a new genus, *Delosina*, to accommodate his *Polymorphina (?) complexa*. He never came to publish this because of the major difficulties he encountered in handling this species, the specimens being small, fragile, and very transparent. Heron-Allen and Earland (1915) established the existence of secondary apertures along the sutures, which gave a 'postage stamp fracture' in broken specimens. Wiesner (1931) found a number of specimens in the material gathered by the German Antarctic Expedition and, by a happy coincidence, proposed the name *Delosina* as a new genus to accommodate what he considered to be the *Polymorphina (?) complexa* of Sidebottom (later studies showed the *Delosina complexa* sensu Wiesner to be two different species). Because of the fact that his specimens were substantially larger, he was able to demonstrate the existence of a canal underlying the sutures, thus showing that the sutural apertures do not communicate directly with the chamber lumen (see Textfig. 1 for a clarification of the anatomical terms used). While working on the material gathered by the *Discovery* and the *William Scoresby*, Earland (1934) revised the genus. Besides this new material he also had the original material of Sidebottom at his disposal and had received the figured specimens of Wiesner. Revising and comparing all this material he erected four more species; *Delosina complanata*, *D. polymorphinoides*, *D. sutilis*, and *D. wiesneri*. Earland also suggested, tentatively, to remove *Delosina* from the Polymorphinidae to the Buliminidae, because he had observed what seemed to be a loop-shaped aperture in the proloculus in one of the sections. He expressed serious doubts, however, about the validity of this move. Cushman (1948) followed Earland's suggestion and placed *Delosina* in the Uvigerininae; Buliminidae. Parr (1950) preferred to erect a separate family for the genus, the Delosinidae. This family was retained by Loeblich and Tappan (1964); they



Textfig. 1 Anatomy of *Delosina*. 1. Ultimate chamber. 2. Penultimate chamber. 3. Trematophore. 4. The cup-shaped feature underlying the trematophore. 5. Subsutural tube, which is a continuation of (4). 6. Sutural openings. 7. The foraminal trematophore, which is entirely contained in the lumen of the next chamber.

placed it in the Cassidulinacea on account of its possession of an optically granular wall, close to the Fursenkoininae because of a certain resemblance between *Delosina* and *Virgulinella*. Haynes (1981) kept *Delosina* in the Buliminidae, closely allied with *Virgulinella*. In the latest classification, Loeblich and Tappan (1984) raised the Delosinidae to the rank of superfamily, comprising the Caucasinidae (Baggatellinae and Caucasininae), the Tremachoridae and the Delosinidae, all within the suborder Rotaliina. Until today, all changes in the taxonomic position of *Delosina* have been based on the gross morphology. The aim of this study is to shed some light

on the true affiliation of *Delosina* by means of detailed observations on its morphology and structure.

Material & Methods

A number of specimens of *Delosina complexa*, whole and sectioned, were observed in the scanning electron microscope. Sections were made following Grønlund and Hansen (1976) and Morkhoven (1958). The sectioned specimens originate from the Arafura Sea, Station 501 of the Danish Galathea Expedition. All specimens housed in the British Museum (Natural History) were studied.

OBSERVATIONS

Observations on intact specimens clearly show the existence of the sutural apertures, which in some cases may be so small as to escape notice under the stereo-microscope (Plate 2, fig. 3). The cribrate aperture, or trematophore, is seen to consist of a series of openings in a rather irregular area between the apex of the ultimate chamber and the sutural line most close to this apex (Plate 1, fig. 2). The openings themselves are quite irregular in outline. In section they show ragged edges (Plate 2, fig. 2), suggesting they may have been formed by resorption rather than being built. Since no veneer can be seen and since the edges, in section, are irregular, it seems likely that they were formed by the dissolution of calcite, starting from, say the pores, instead of being left open during the calcification process. The pores in the wall are minute (Plate 1, figs 3, 4) and most of the time irregular in shape. Some specimens have a surprising low density of pores. The sections show very clearly the subsutural tubes (Plate 1, figs 1, 5, 6; Plate 2, figs 1, 3, 4), including the cup-shaped prolongation of this tube underlying the trematophore (Plate 1, fig. 4; Plate 2, fig. 1; see also Earland 1934, p. 126, point iv). The sutural openings are quite numerous (Plate 1, fig. 6); in contrast, the number of openings from the tube towards the chamber lumen is very low (Plate 2, fig. 4). A few of these openings towards the lumen can also be seen in the broken specimen of Wiesner (1931, Plate 21, fig. 256; slide BMNH ZF 3226).

From a structural point of view some remarkable observations can be made. The wall structure is non-lamellar. It consists of small, blocky crystalline elements, somewhat reminiscent of the microgranular type of structure but differing from the latter in being irregular (Plate 2, fig. 6). This is a new type of wall structure, it has no known equivalent in the calcite-secreting Foraminifera.

It is worth noting that the monolamellar taxa in the Rotaliina, i.e. the Nodosariidae, show a radial wall structure, both optically and ultrastructurally (Grønlund and Hansen, 1976).

Secondary lamination is absent (Plate 1, fig. 3; Plate 2, figs 1, 5). When a new chamber is added, the remainder of the test is not covered by an extra layer of calcite. This is, again, a fundamental deviation from the general pattern within the Rotaliina. The few taxa that exhibit the lack of secondary lamination (one species in the Nodosariidae and a few in the very primitive Syzraniidae, which are now classified in the Lagenina) have a radial wall when viewed under polarized light.

Following the rationale behind the latest classification scheme (Loeblich and Tappan, 1984), *Delosina* should be separated from all the other perforate calcitic Foraminifera. I therefore propose to erect a new suborder, the Delosinina.

Although originally included in the Delosinacea, I do not consider the Caucasinidae and the Tremachoridae to be member taxa of the Delosinina. The genus *Caucasina* possesses a toothplate, a bilamellar granular type of wall structure and shows secondary lamination. These features suffice to put it in the Buliminacea. I do not consider the optical nature of the wall structure to be a character sufficient to warrant the separation of families. The genus *Tremachora* remains an enigmatic taxon. Since no data are available as to the internal morphology nor the ultrastructure of the wall, I prefer to consider the taxonomic position of *Tremachora* as uncertain until more information becomes available.

A puzzling fact concerning *Delosina* is the apparent absence of a geological record. Although it shows some advanced morphological features, the absence of secondary lamination and especially the wall structure points towards a long geological history. In the scheme proposed by Hansen (1979), *Delosina* would belong somewhere between the micro-granular group and the group secreting optically orientated calcite, two groups with a substantial geological record. A possible reason for the absence of *Delosina* in the fossil record can be found in the very fragility of the test. The fact that the successive chambers are joined only by the rims of the subsutural tubes (Plate 1, fig. 6) without subsequent reinforcing secondary lamination results in a very fragile test (the specimens are difficult to handle, they break easily, even when using a brush carefully). It is doubtful that the tests of *Delosina* would survive the rough average taphonomical treatment, especially since *Delosina* occurs in the more shallow water zones.

SYSTEMATICS

Order: FORAMINIFERIDA Eichwald, 1830

Suborder: DELOSININA subord. nov.

Test multilocular, chambers arranged in coils; chambers simple; wall calcareous, composed of very small, blocky, irregular crystalline units, monolamellar; secondary lamination absent.

Family: DELOSINIDAE Parr, 1950

Test triserial, may become biserial, or biserial throughout; wall perforate, appearing optically indistinctly granular; aperture a trematophore which may be absent; sutures with sutural openings which give access to a subsutural tube.

Genus: *DELOSINA* Wiesner, 1931

TYPE SPECIES. *Polymorphina (?) complexa* Sidebottom, 1907

DESCRIPTION. Test free, elongate, or extremely inflated, rounded in section, may be laterally compressed. Chambers arranged in coils, usually triserial, may become biserial, or biserial throughout. Chambers embracing, usually starting

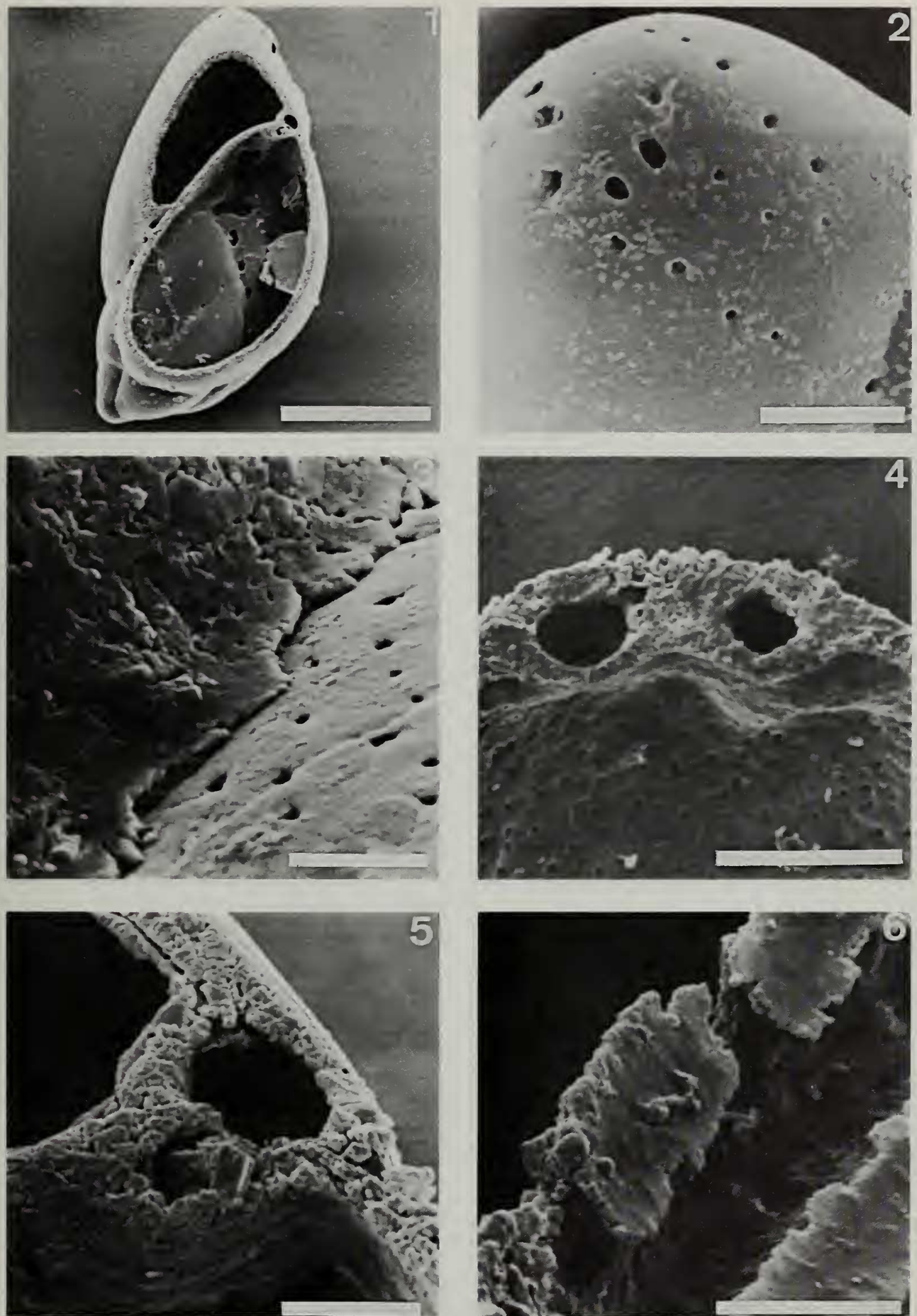


Plate 1 *Delosina complexa*, Arafura Sea. Fig. 1. A partially sectioned specimen, showing the trematophore, subsutural tubes, sutural openings and the general disposition of the chambers. Scale bar: 100 μm. Fig. 2. A close-up of the trematophore. Note the larger openings surrounded by a series of smaller openings lying in a loop around the apex. Scale bar: 20 μm. Fig. 3. Internal view showing how a chamber joins a previous one without secreting extra layers of calcite, as the line of contact and the pores of the previous chamber clearly demonstrates. Scale bar: 3 μm. Fig. 4. Part of the cup-shaped feature underlying the trematophore. Note that this cup is not a chamberlet but an enlarging of the subsutural tube. Scale bar: 20 μm. Fig. 5. A close-up of Fig. 1, showing the subsutural tubes of ultimate and penultimate chamber. Scale bar: 10 μm. Fig. 6. A view of the inside of the subsutural tube, seen from the lumen side, showing the sutural openings and the constructional relationship between the tube and the wall of the previous chambers. Scale bar: 20 μm.

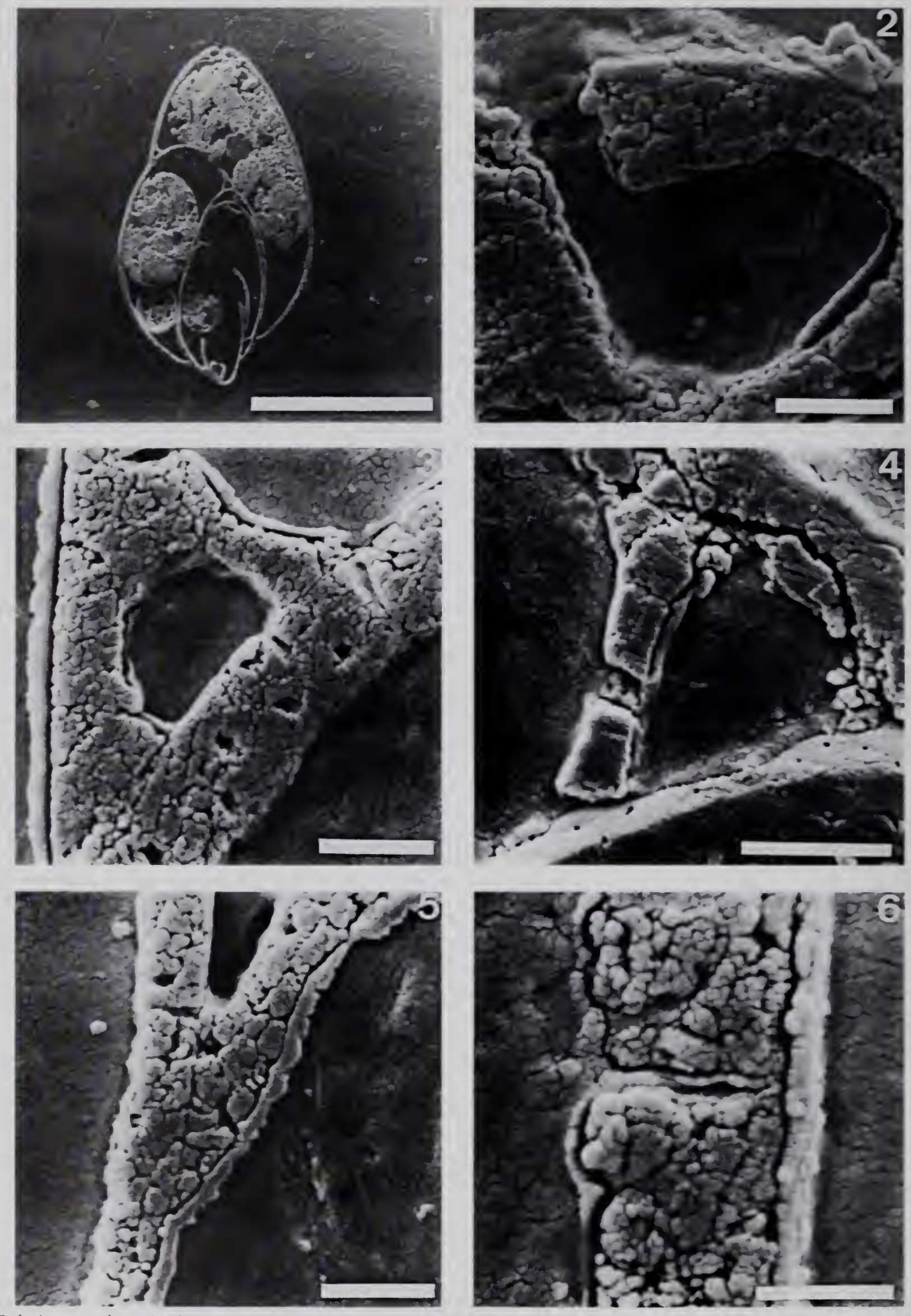


Plate 2 *Delosina complexa*, Arafura Sea. Etched sections. Fig. 1. A general view, showing the disposition of the chambers, subsutural tubes and cup-shaped features underlying the trematophore. Scale bar: 200 μm. Fig. 2. A section through the trematophore. Note the coarse edges on the opening. Scale bar: 5 μm. Fig. 3. A close-up of the contact between two chambers, with a subsutural tube. Note that no septal flap is formed. Note also the absence of structure in the walls, including the subsutural tube. Scale bar: 5 μm. Fig. 4. A subsutural tube with an opening towards the lumen. Scale bar: 10 μm. Fig. 5. Contact between two chambers, showing the absence of secondary lamination. Scale bar: 5 μm. Fig. 6. A close-up of the ultrastructure of the wall, showing it to be composed of very small, blocky crystal units, irregularly placed against each other, in contrast with the regular arrangement seen in microgranular walls. Scale bar: 3 μm.

very close to the proloculus, may become more evolute, especially when becoming biserial. Sutures somewhat marked, lying at the edge of a depression where the chambers adjoin, punctured by a series of small openings, the secondary apertures, which give access to a subsutural tube. The aperture, which may be absent, is a trematophore lying at the apex of the chamber, extending down to the nearest suture. Inside the chamber the trematophore is isolated from the lumen by a cup-shaped feature, which itself is continuous with the subsutural tube (the cup-shaped feature is absent if the trematophore is lacking). The subsutural tube allows some access to the chamber lumen through a low number of openings. Ornamentation is absent.

Delosina complexa (Sidebottom)

Pl. 1, figs 1–6; Pl. 2, figs 1–6; Pl. 3, figs 1–2.

1907 *Polymorphina (?) complexa* Sidebottom: (*pars*), 16, textfigs 3–7, Pl. 51, figs 1–7 (only).
1915 *Polymorphina complexa* Sidebottom; Heron-Allen and Earland: 673–674, Pl. 51, figs 1–3.
1918 *Polymorphina complexa* Sidebottom; Sidebottom: 145, Pl. 5, figs 13–14.
non 1931 *Delosina complexa* (Sidebottom); Wiesner: 123, Pl. 21, figs 254–256.
1934 *Delosina complexa* (Sidebottom); Earland: 127–128, not illustrated.
1934 *Delosina polymorphinoides* Earland: 128–129, not illustrated.
1939 *Delosina complexa* (Sidebottom); Heron-Allen and Earland: 177, not illustrated.

MATERIAL. BMNH. 3 slides, Delos, Sidebottom collection (*pars*). 1 slide, Delos, Heron-Allen and Earland collection. 1 slide, The Lido, Venice, Italy, Heron-Allen and Earland collection. 1 slide, Bay of Naples, Italy (labelled *Polymorphina complanata*), Heron-Allen and Earland collection. BMNH 1969:4:30:112:cell 63, Ebro Delta, Spain, Scrutton collection. BMNH 1965:11:92 and 93, Torbay, S. Devon, England, Milton collection (*pars*), and 1965:11:25:91, ibid., id. (labelled *Polymorphina complanata*). 1 slide, Baron Heads, Victoria, Australia (labelled *P. complanata*), *dedit* Parr. BMNH 1955:10:21:110, Kerimba Archipelago, Heron-Allen and Earland collection (labelled SYNTYPE *Delosina polymorphinoides*). Slide TS 641, cell 73 (*pars*), South Orkneys, *Discovery* station 170, Heron-Allen and Earland collection. Specimens from the Arafura Sea, *Galathea* station 501, Zoological Museum, Copenhagen, Denmark. Specimens from the Ebro Delta, Spain, J. W. Murray coll., Geologisk Central Institut, Copenhagen, Denmark.

LECTOTYPE. BMNH ZF 4725, Delos, Greece. Figured in Plate 3, figs 1, 2.

DESCRIPTION. Test free, slender, ovate, maximum width slightly above the middle of the test, triserial; chambers embracing, ellipsoid drawn out, well rounded, sutures somewhat depressed, sharply delineated, gently curved, punctured by sutural apertures which allow immediate access to a subsutural tube which ends in a cup-shaped feature underlying the trematophore-like aperture at the apex of the chamber, tube and sutural openings barely visible in the light-microscope (150 X); trematophore a series of coarse perforations running up from the sutural base almost to the apex of the chamber; wall calcareous, hyaline, very finely perforate, optically granular. Lectotype with 7 chambers; test length: 405 μm, width: 284 μm.

REMARKS. Sidebottom's *P. (?) complexa* contained two discrete species. The specimens figured by Sidebottom (1907, Pl. 51, figs 8, 9) were renamed by Earland (1934) as *Delosina complanata*.

It seems that a clear dimorphism is present in this species. The individuals with a very small proloculus answer the description of the lectotype; individuals with a larger proloculus appear as being somewhat compressed laterally, and the last chamber(s) show a tendency of becoming rectilinear.

The only specimen referable to *Delosina polymorphinoides* Earland, 1934, seems to be a good *D. complexa*, only with more inflated chambers. Since different degrees of inflation are present in the material, and since the specimens intergrade freely, I consider *D. polymorphinoides* to be the same species as *D. complexa*.

According to Dr Hounsome, Manchester Museum, no specimens of *Polymorphina complexa* are present in the collections of that Museum, thus confirming Earland's statement that Sidebottom had sent him all his material (Earland 1934, p. 125).

DISTRIBUTION. Recent. North Sea, Mediterranean, Indo-Pacific and Antarctic province (see Textfig. 2).

Delosina complanata Earland

Pl. 3, figs 3–4.

1907 *Polymorphina (?) complexa* Sidebottom: (*pars*), 16, Pl. 51, figs. 8–9 only.
1916 *Polymorphina complexa* Sidebottom; Heron-Allen and Earland: 48, Pl. 8, figs. 5–7.
1934 *Delosina complanata* Earland: 128, not illustrated.

MATERIAL. BMNH. Slides from Delos, Greece (labelled *P. complexa*, *pars*) Sidebottom collection. Slide TS 512, cell 42 (*pars*), *William Scoresby*. BMNH 1965:11:25:92 and 93, Torbay, S. Devon, England, Milton collection (*pars*). BMNH 1955:10:25:290, Cornwall, England (labelled SYNTYPE), Heron-Allen and Earland collection.

LECTOTYPE. BMNH 1955:10:25:290. Figured in Plate 3, figs 3–4.

DESCRIPTION. Test free, elongate, sides almost parallel, gently rounded, chambers opposite, giving a compressed appearance, coiling axis may be gently curved; chambers elongate, well rounded; sutures sharply marked at the contact between the chambers, somewhat undulate, punctured by small openings, the sutural apertures which give access to the subsutural tube, this tube can be seen as a faint extra line running parallel with the suture, thickening at the top of the previous chamber, giving the impression of a very small lip; trematophore and the cup-shaped feature are absent; wall calcareous, hyaline, finely perforate. Lectotype, test length: 335 μm, width: 167 μm.

REMARKS. Differs from the megalospheric specimens of *D. complexa* in having no trematophore, and in being biserial throughout.

DISTRIBUTION. Recent. North Sea, Mediterranean and Falklands (see Textfig. 2).

Plate 3 Figs 1, 2. Lectotype of *Delosina complexa* (Sidebottom), Delos, Greece. Scale bar: 200 μm. Figs 3, 4. Lectotype of *Delosina complanata* Earland, Cornwall, England. Scale bar: 100 μm. Figs 5, 6. Lectotype of *Delosina sutilis* Earland, South Orkneys. Scale bar: 500 μm.

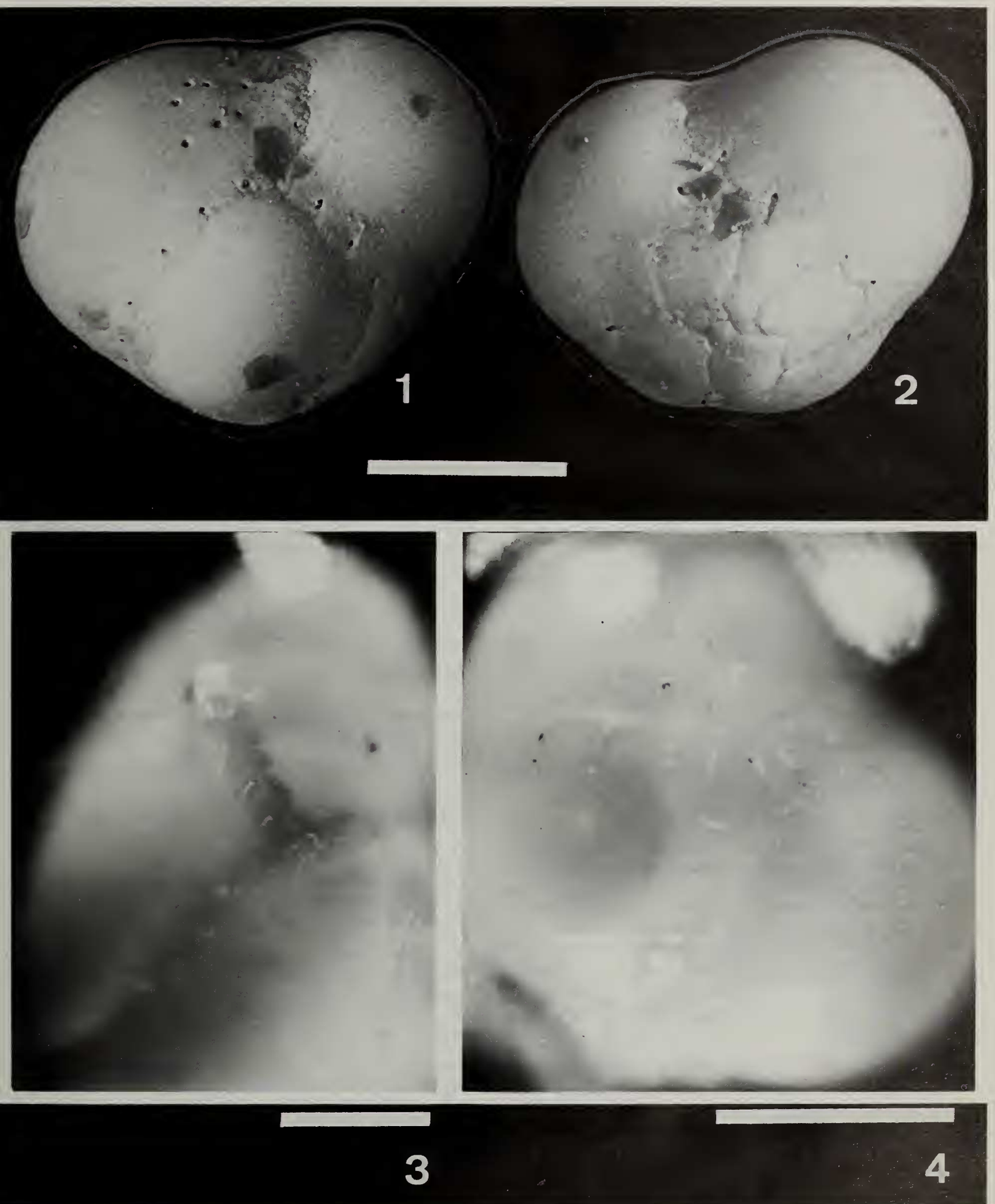
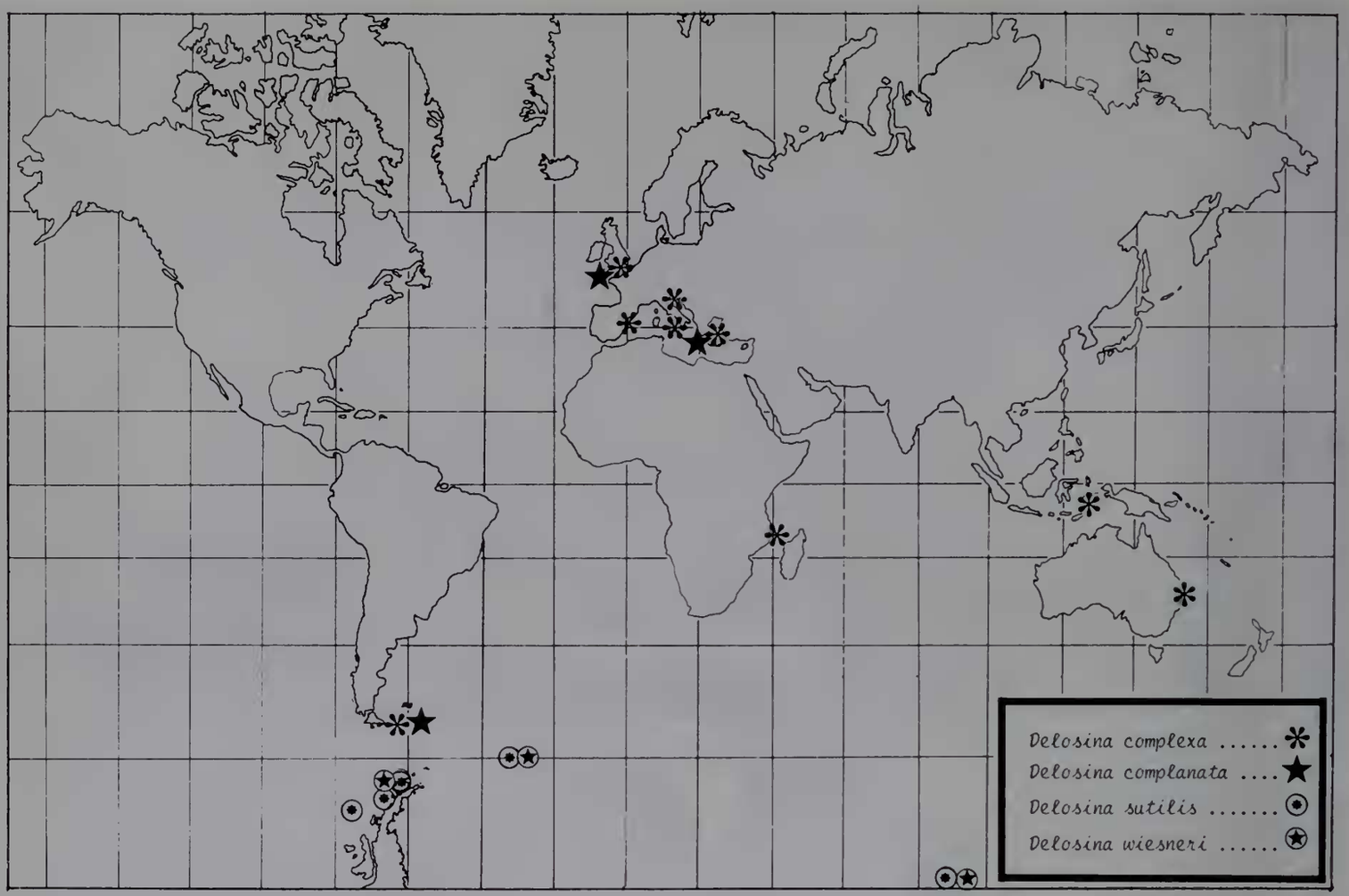


Plate 4 Figs 1, 2. Lectotype of *Delosina wiesneri* Earland, South Sandwich Islands. Scale bar: 200 μm. Fig. 3. Light microscope photograph of *Delosina sutilis*, immersed, showing the small canals which connect the sutural openings with the subsutural tube. Scale bar: 200 μm. Fig. 4. Light microscope photograph of *Delosina wiesneri*, immersed, neatly showing the almost dendritic pattern of the canals between subsutural tubes and sutural openings. Scale bar: 200 μm.



Textfig. 2 The geographical distribution of *Delosina*.

Delosina sutilis Earland

Pl. 3, figs 5–6, Pl. 4, fig. 3.

1931 *Delosina complexa* (Sidebottom); Wiesner: (*pars*), 123, Pl. 21, fig. 254 only.
1934 *Delosina sutilis* Earland: 129, Pl. 5, figs 1–8.

MATERIAL. BMNH. Slides ZF 3229, ZF 3228, South Shetlands, *Discovery*, and 3 balsam embedded specimens, Heron-Allen and Earland collection. BMNH 1955:11:3:258, a balsam embedded section. Slides TS 627, cell 61; TS 641; cell 73 (*pars*); TS 642, cell 75; TS 660, cell 69 (*pars*); all type slides *Discovery*, Heron-Allen and Earland collection. BMNH ZF 3226 (*pars*), out of Kaiser Wilhelm's Land, Antarctica, Wiesner collection.

LECTOTYPE. BMNH ZF 4726, South Orkneys. Figured in Plate 3, figs 5–6.

DESCRIPTION. Test free, elongate, large, ovate, greatest width around the middle of the test, triserial; chambers large, somewhat inflated, embracing; sutures at the edge of a band-like depression between the chambers, gently curved, punctured by comparatively small sutural openings which give access to a narrow, gently curved canal which opens into the subsutural tube, forming a branching-like network; aperture a prominent trematophore; wall calcareous, semi-opaque, very finely perforate. Lectotype, test length: 1130 μm, width 720 μm.

REMARKS. Differs from *D. complexa* in being substantially larger and in possessing a band-like depression between the chambers in which canals connect the sutural openings with the subsutural tube.

DISTRIBUTION. Recent. Antarctic province, (see Textfig. 2).

Delosina wiesneri Earland

Pl. 4, figs 1, 2, 4.

1931 *Delosina complexa* (Sidebottom); Wiesner: (*pars*), 123, Pl. 21, figs 255–256 only.
1934 *Delosina wiesneri* Earland: 130, Pl. 5, figs 9–15.

MATERIAL. BMNH. Slides ZF 3227, ZF 3225, South Sandwich Isles, resp. South Orkneys, *Discovery*. Slides TS 660, cell 69 (*pars*), *Discovery*; Heron-Allen and Earland collection. Slide ZF 3226, off Kaiser Wilhelm's Land, Antarctica (*pars*), Wiesner collection.

LECTOTYPE. BMNH ZF 3227a, South Sandwich Islands. Figured in Plate 4, figs 1–2.

DESCRIPTION. Test free, stout, almost twice as broad as long, triserial; chambers extremely inflated, almost spherical, somewhat embracing; sutures at the edge of a band-like depression between the chambers, punctured by very small sutural openings which are the outer ends of canals, which gently curve away from the subsutural tube; the trematophore is very irregular, a few coarse punctations in an area usually lying close to the suture between the ultimate and the penultimate chamber; wall calcareous, semi-opaque, very

finely perforate. Lectotype, test length: 310 μm, width: 400 μm.

REMARKS. Somewhat similar to *D. sutilis*, but differing in being extremely inflated and in possessing a very irregular and often obscure trematophore.

DISTRIBUTION. Recent. Antarctic province (see Textfig. 2).

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